

Filling in the Gaps: Xenoliths in Meteorites are Samples of “Missing” Asteroid Lithologies

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We know that the stones that fall to earth as meteorites are not representative of the full diversity of small solar system bodies, because of the peculiarities of the dynamical processes that send material into Earth-crossing paths [1] which result in severe selection biases. Thus, the bulk of the meteorites that fall are insufficient to understand the full range of early solar system processes. However, the situation is different for pebble- and smaller-sized objects that stream past the giant planets and asteroid belts into the inner solar system in a representative manner. Thus, micrometeorites and interplanetary dust particles have been exploited to permit study of objects that do not provide meteorites to earth. However, there is another population of materials that sample a larger range of small solar system bodies, but which have received little attention – pebble-sized foreign clasts in meteorites (also called xenoliths, dark inclusions, clasts, etc.). Unfortunately, most previous studies of these clasts have been misleading, in that these objects have simply been identified as pieces of CM or CI chondrites. In our work we have found this to be generally erroneous, and that CM and especially CI clasts are actually rather rare. We therefore test the hypothesis that these clasts sample the full range of small solar system bodies.

We have located and obtained samples of clasts in 81 different meteorites, and have begun a thorough characterization of the bulk compositions, mineralogies, petrographies, and organic compositions of this unique sample set. In addition to the standard e-beam analyses, recent advances in technology now permit us to measure bulk O isotopic compositions, and major- though trace-element compositions of the sub-mm-sized discrete clasts. Detailed characterization of these clasts permit us to explore the full range of mineralogical and petrologic processes in the early solar system, including the nature of fluids in the Kuiper belt and the outer main asteroid belt, as revealed by the mineralogy of secondary phases.

Reference: [1] Vokrouhlický D. and Farinella P. (2000) Efficient delivery of meteorites to the Earth from a wide range of asteroid parent bodies. *Nature* **407**, 606-608.